

**Front End Shutters  
Interface Control Document  
for the  
Generation-3  
Personnel Safety System  
(PSS)  
of the  
Advanced Photon Source  
at  
Argonne National Laboratory  
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**WBS X.1.4.1.4**

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## 1. INTRODUCTION

### 1.1. SCOPE


This document covers the technical interfaces between the generation 3 PSS and the front-end shutters.

Technical groups involved are ASD Safety Interlock Group, ASD Vacuum Group, XFD Engineering Group and Mechanical Engineering Group.

### 1.2. DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

The following are some of the frequently appearing or unique acronyms used in this document. This list is provided as a quick reference for the reader's convenience.

ACIS Access Control Interlock System  
 APS Advanced Photon Source  
 ASD Accelerator Systems Division  
 DOE Department Of Energy  
 ES&H Environment, Safety & Health Manual  
 PSS Personnel Safety System  
 PLC(s) Programmable Logic Controller(s)  
 SAD Safety Assessment Document  
 XFD Experimental Facilities Division

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### 1.3. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein.

#### APS Documents

Document No. 1111-00001 APS Quality Assurance Plan, dated May 1990.

#### Drawings

##### PS1 Mechanical Drawings

Drawing No. beamline dependent – Overall Assembly

Drawing No. beamline dependent – Switch Holder Assembly

##### PS2 Mechanical Drawings

Drawing No. beamline dependent – Overall Assembly

Drawing No. beamline dependent – Switch Holder Assembly

##### SS1 Mechanical Drawings

Drawing No. beamline dependent – Overall Assembly

Drawing No. beamline dependent – Switch Holder Assembly

##### SS2 Mechanical Drawings

Drawing No. beamline dependent – Overall Assembly

Drawing No. beamline dependent – Switch Holder Assembly

##### Pneumatic Control Schematic

Drawing No. beamline dependent


##### Electrical Control Schematics

Drawing Nos. beamline dependent

#### Precedence

In the event of conflict between the provisions of this specification and other documents, the following precedence shall apply:

The documents specified in section 1.4 References as applicable to this document.  
This specification.

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## 1.4. REFERENCES

### Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein.

In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

Department of Energy (DOE) ORDER 420.2A, 01-08-01  
Accelerator Safety Implementation Guide for DOE O 420.2A, Draft, August 2001  
DOE ORDER 5480.25, 11-3-92  
DOE GUIDANCE 5480.25, September 1, 1993

DOE ORDER and GUIDANCE 5480.25 are included because they were in effect and referenced when the Safety Assessment Document (SAD) was originally written; it has been superseded by DOE ORDER 420.2, which has been superseded by DOE ORDER 420.2A. DOE ORDER 420.2(A) essentially made the approved SAD the effective regulatory document.

Copies of specifications, standards, drawings and publications required by suppliers in connection with specified procurement functions should be obtained from the contracting agency or as directed by the contracting office.

### Non-Government Documents

The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

Environment Safety & Health Manual, Section 5.16 (ES&H 5.16) April 25, 2003, Argonne National Laboratory.

APS Safety Assessment Document (SAD), Rev 1, May 1999, Argonne National Laboratory, Argonne, IL.

### Compliance with the following required by SAD:


Stanford Linear Accelerator Center Report 327 (SLAC 327), April 1988, Stanford Linear Accelerator Center, Menlo Park, CA.

National Council on Radiation Protection Report No. 88 (NCRP 88), Issued 30 December 1986, National Council on Radiation Protection.

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal Agencies.


Document No. 1111-00001-00 APS Quality Assurance Plan, dated May 1990.



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## 1.5. NOTES & EXCEPTIONS

All Input Signals are High True unless otherwise noted.

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## 2. EQUIPMENT AND RESPONSIBILITIES

### 2.1 OVERVIEW

There are four shutters in each beamline front-end under PSS control: safety shutters SS1 and SS2; photon shutters PS1 and PS2. Usually PS1 remains open, whereas PS2, SS1, and SS2 are commanded open/closed to allow/inhibit x-rays into the beamline, or are tripped to the closed state if PSS detects a condition that may lead to unsafe operation. In the latter situation, PS1 is used as a backup to PS2.

Each shutter is pneumatically controlled, and has redundant position limit switches at each end of its travel that provide essential status information to PSS and to ACIS.

### 2.2 GENERAL RESPONSIBILITIES AND INTERFACES

XFD Engineering Group is responsible for all mechanical aspects of the design, fabrication, installation, and commissioning of the photon- and safety-shutter devices.


XFD Engineering Group is responsible for the design, fabrication, installation, alignment, and commissioning of limit switch.

Following commissioning, responsibility for maintenance of mechanical and pneumatic aspects of the photon- and safety-shutters shall be transferred to ASD Vacuum Group. Responsibility for the limit switches and electrical wiring shall be transferred to ASD Safety Interlocks Group. In support of this, XFD Engineering Group will provide complete as-built engineering drawings, bill of materials and written procedures for aligning and positioning the limit switches.

ASD Vacuum Group is responsible for the design, fabrication, installation, and commissioning of the pneumatic control system that moves the shutter device to/from the 'open' and 'closed' positions. This includes the cylinder solenoid and its electrical connector.

ASD Mechanical Engineering Group will be responsible for maintenance of flow and pressure monitoring components, piping, hoses, valving and insuring that required flow and pressure is maintained.

ASD Safety Interlock Group is responsible for all aspects of the PSS and ACIS systems that implement safety logic and control associated with the photon- and safety-shutters. ASD Safety Interlock Group is also responsible for electrical wiring between the PSS & ACIS systems and position limit switches.

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## 2.3 GENERAL TECHNICAL REQUIREMENTS

XFD Engineering Group shall specify the maximum allowable time from sending a shutter ‘open’ command to the ‘open’ switches being made up, and from disabling the ‘open’ command to the ‘closed’ switches.

For maintenance and PSS validation purposes, it is desirable to have a method of operating the shutter solenoids both close to the front-end and at the storage ring mezzanine. ASD Safety Interlocks Group will provide a means through PSS to electrically control and monitor the status of each photon and safety-shutter from both the storage ring mezzanine level and from inside the storage ring tunnel.


For LOTO purposes, a lockable mechanical valve supply is required on the pneumatics’ that feeds the PS2, SS1 and SS2 front-end shutters. This must be accessible from outside the storage ring tunnel. Closing the valve shall exhaust the downstream pneumatic line. The PS1 shutter is not a part of the PSS Safety Shutter cluster and is handled differently as described below.

An electrically controlled solenoid shall be provided to allow remote isolation of the air supply to PS2, SS1, and SS2. This will be energized by ACIS when the beamline is Global Online. De-energizing the valve shall exhaust the downstream pneumatic line to atmosphere. The is in compliance with the SAD section 3.12.2.4.1 PSS Testing Overview. The PS1 shutter is handled different from PS2, SS1 and SS2 as described below.

The PS1 shutter is not part of the Front End Shutter Safety cluster. Its purpose its to provide a means of protecting SS1 and SS2 in the case where PS2 does not close, without dumping the storage ring. Beam position monitoring requires the PS1 shutter to be open. By special request, PS1 may be closed for PSS beamline maintenance or validation. Normal PSS validations and maintenance requires only PS2, SS1 and SS2 to be closed. This allows storage ring operations to proceed normally with a maximum number of BPMs even though the PSS is being validated or maintained.

The solenoids used to operate PS1, PS2 SS1, and SS2 must be failsafe. They must close when not supplied with the open signal (+24VDC) from the PSS and supply air to the close cylinder port of the shutter. Each solenoid will have visual indicator to show when it is energized. Each solenoid will also have a mechanical override to allow local operation for testing purposes. The mechanical override must be of the self resetting type and not latch the solenoid open when activated.

For PSS validation purposes, it shall be possible to depress the individual ‘open’ limit switches using a screwdriver when the shutter is in the ‘closed’ position, and to depress the individual ‘closed’ limit switches when the shutter is in the ‘open’ position.

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## 2.4 SAFETY IMPLICATIONS OF SHUTTER COMPONENTS

The shutters are an integral part of the PSS safety system, and are relied upon to protect personnel from prompt radiation hazards. Integrity and reliability of the control and read back signals is paramount to the integrity of the safety system, and hence to the protection of personnel.

Any time the shutter ‘closed’ switches are made up, the shutter shall completely block the beam. This places specific requirements on the alignment and size of the shutter, and on the limit switch location, ‘slop,’ repeatability, and mechanical hysteresis. There shall be at least 1-2mm over-travel on position switches to prevent nuisance trips.


Limit switches for all shutter devices shall be positioned such that the beam is completely stopped when the shutter ‘closed’ switches are made up. Likewise, the shutter shall be completely out of the path of the beam any time the shutter ‘open’ switches are made up.

Since the shutters take a finite time to close, there is a timer in the PSS plc code to ignore shutter status faults while the device is being driven open or closed. Failure of the device to open and/or close in the specified time will generate a PSS fault. ASD Safety Interlocks Group shall implement this timer according to specifications provided by XFD Engineering Group

XFD Engineering Group shall make provision in the design to protect from tampering or accidental damage all devices connecting with PSS and/or ACIS. All such devices shall be clearly marked as being part of the personnel safety system. For the limit switches, this is currently done with yellow ‘ACIS’ stickers that seal in place a Lexan cover over the switches.

Configuration control is required for all safety-related devices and associated interfaces, and specific work procedures shall be followed by anyone working on such systems.

For personnel safety reasons, all control and monitoring devices shall be ‘fail-safe’. Hence, position limit switches and pressure switches shall fail with their contacts ‘open,’ and solenoid valves fail with the valve ‘closed.’

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### 3. INTERFACE CHARACTERISTICS

Control signals (From PSS to shutters)

“PS1 Open” command: 24v = open PS1 shutter, 0v = close PS1 shutter

“PS2 Open” command: 24v = open PS2 shutter, 0v = close PS2 shutter

“SS1 Open” command: 24v = open SS1 shutter, 0v = close SS1 shutter

“SS2 Open” command: 24v = open SS2 shutter, 0v = close SS2 shutter

“Enable pneumatic supply” command:

24v = enable the pneumatic supply to PS2, SS1, and SS2

0v = inhibit and exhaust the pneumatic supply to PS2, SS1, and SS2.

NOTE: PS1 is supplied from a source separate from PS2, SS1 and SS2.

All solenoid valves shall require continuous power to remain open.

Removal of power will cause the solenoid to positively close.

Loss of the pneumatic supply shall cause all shutters to self-close.

Shutters shall close completely should the pneumatic supply fail.

Load current for each solenoid valve should not exceed 100mA.

Read back signals (From shutters to PSS/ACIS).

There are four separate position switches on each shutter: two switches provide independent indication that the shutter is closed; the other two provide independent indication that the shutter is open. The closed status switches are connected directly to the ACIS. The ACIS relay isolates and send the signals to the PSS and the FE-EPS. The open status switches are connected to the PSS. The PSS relay isolates the signal and sends the signal to the FE-EPS. The pressure switch signals are sent only to the PSS. The complete list of signals is as follows

“PS1 Open status to Chain A”: contact closed = PS1 is at ‘open’ end stop

“PS1 Open status to Chain B”: contact closed = PS1 is at ‘open’ end stop

“PS1 Closed status to Chain A”: contact closed = PS1 is at ‘closed’ end stop

“PS1 Closed status to Chain B”: contact closed = PS1 is at ‘closed’ end stop

“PS2 Open status to Chain A”: contact closed = PS2 is at ‘open’ end stop

“PS2 Open status to Chain B”: contact closed = PS2 is at ‘open’ end stop

“PS2 Closed status to Chain A”: contact closed = PS2 is at ‘closed’ end stop

“PS2 Closed status to Chain B”: contact closed = PS2 is at ‘closed’ end stop


“SS1 Open status to Chain A”: contact closed = SS1 is at ‘open’ end stop

“SS1 Open status to Chain B”: contact closed = SS1 is at ‘open’ end stop

“SS1 Closed status to Chain A”: contact closed = SS1 is at ‘closed’ end stop

“SS1 Closed status to Chain B”: contact closed = SS1 is at ‘closed’ end stop

“SS2 Open status to Chain A”: contact closed = SS2 is at ‘open’ end stop

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“SS2 Open status to Chain B”: contact closed = SS2 is at ‘open’ end stop  
 “SS2 Closed status to Chain A”: contact closed = SS2 is at ‘closed’ end stop  
 “SS2 Closed status to Chain B”: contact closed = SS2 is at ‘closed’ end stop

Additionally, there are independent pressure switches as follows:

“Pneumatic pressure below 3 PSI status to Chain A”: contact closed = pressure below 3 PSI  
 “Pneumatic pressure below 3 PSI status to Chain B”: contact closed = pressure below 3 PSI  
 “Pneumatic pressure above 60 PSI status”: contact closed = pressure above 60 PSI  
 Note: the 60-PSI status signal operates a relay. The normally open relay contacts provide Chain-A and Chain-B isolated fail safe 60 PSI status.

## 3.1 PSS LOGIC SEQUENCES

### 3.1.1 Open front-end shutters

The PSS commands SS1 and SS2 to open

The PSS waits for SS1 and SS2 ‘open’ switches to show the shutters are open for 1 second.

The PSS commands PS2 to open. If PS1 has not been previously opened The PSS will open PS1 simultaneously.

### 3.1.2 Close front-end shutters

The PSS commands PS2 to close


If PS2 does not close within 3 seconds the PSS will command PS1 to close.

If either PS2 or PS1 ‘closed’ switches show fully closed for 1 second. PSS commands SS1 and SS2 to close.

If at the end of 10 seconds SS1 and SS2 ‘closed’ switches do not show closed the PSS will record the reason for failure.

### 3.1.3 PS1 operation

The PS1 shutter is normally operated independently from PS2, SS1 and SS2. The signals controlling PS1 operation come from the Front End Equipment Protection System (FE-EPS). FE-EPS makes a request of the PSS to open or close the PS1 shutter. If PS2, SS1 and SS2 are closed the PSS will comply with the FE-EPS request to open or close PS1. If PS1 is closed and the permits are present to allow operation of PS2, SS1 and SS2, when PS2 is opened the PSS will also open PS1. If a FE-EPS open request is present for PS1 will be left open when PS2 is closed unless PS2 fails to close. If a FE-EPS open request is not present for PS1 when PS2 is closed, PS1 will also be closed.

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## 3.2 PNEUMATIC PRESSURE SWITCHES

### 3.2.1 “>60 PSI “

This signal is used to sense that there is sufficient air pressure to properly control the SS1 and SS2 shutters at all beamlines. With the exception of beamlines 23-ID and 24-ID this same signal will sense that there is sufficient air pressure to properly control the PS2. At beamlines 23-ID and 24-ID the PS1 and PS2 photon shutters require a minimum of 30 PSI to operate, but the operating pressure must be no more than 40 PSI in order to protect the metal bellows used to drive these devices. The expected life cycle of these bellows will be significantly reduced if this criterion is not met. One sensor provides closed contacts to the PSS. This sensor is located downstream of the global on/off line valve. The 60-PSI status signal operates a relay. The normally open relay contacts provide Chain-A and Chain-B isolated fail safe 60 PSI status.

### 3.2.2 “<3 PSI”

This signal is used to confirm that downstream pneumatic lines are vented when the beamline is Global Offline. It implies there is insufficient air pressure to allow any of the shutters to be moved or to be held in an intermediate position.

Redundant sensor normally open contacts independently provide PSS Chain-A and Chain-B a logic true (+24VDC) when the air pressure falls below 3psi.

When the beamline is taken “Global Offline,” the pneumatic supply is vented. This signal is used to confirm that the air supply and air lines have indeed been vented.

### 3.2.3 Pressure sensor cross check

The < 3 psi signals and the > 60 psi signals are verified to operate correctly against the ACIS Global On-Line signal by the PSS each time the ACIS Global On-Line signal changes state. Additionally, the < 3 psi and the > 60 psi signals are verified against each other continuously. A PSS fault is reported if the PSS detects improper operation of the pressure switches relative to the ACIS Global On-Line signal. These pressure switches are used by the PSS to insure the energy source has in fact been removed when Global Off-Line, and the PSS has adequate pressure to operate the shutters with in the required time constraints when Global On-Line.